associated with T2 values. Daily fat consumption (g) as well as burger consumption correlated with cartilage T2 (P = 0.0305 and P = 0.0264).

Conclusions: Increased BMI and abdominal circumference were strongly associated with increased cartilage degeneration as measured with T2 relaxation time at the knee in individuals without radiographic OA, but other parameters of the metabolic syndrome such as type II DM, hypertension and fat consumption also correlated with higher T2 values. Consequently, this study highlights the impact of the individual components of metabolic syndrome and life style risk factors on cartilage T2 which is a measure of cartilage degeneration. Modification of these factors may have a beneficial effect on preventing early osteoarthritis.

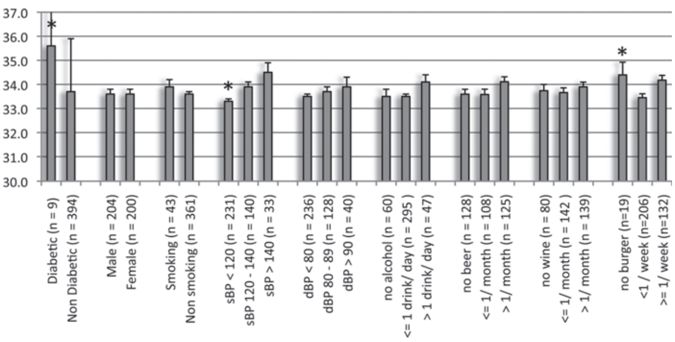

Fig. 1. Mean global T2 values at the knee listing life style factors and conditions affecting T2 values. *p < 0.05.

	Comp.	p	P-value (adjusted)	R-square (adjusted)	t-ratio (adjusted)
Abdominal cirumference	all	<0.0001	**<0.0001**	0.126	6.090
	PAT	0.036	**0.156**	0.045	1.420
	MFC	0.017	**0.213**	0.125	1.250
	MT	<0.0001	**<0.0001**	0.126	6.020
	LFC	0.107	**0.270**	0.005	1.100
	LT	<0.0001	**<0.0001**	0.175	7.240
Body mass index	all	<0.0001	**<0.0001**	0.231	7.180
	PAT	0.004	**0.039**	0.052	2.070
	MFC	0.014	**0.296**	0.126	1.040
	MT	<0.0001	**<0.0001**	0.142	6.660
	LFC	0.228	**0.636**	0.045	0.470
	LT	<0.0001	**<0.0001**	0.190	7.920
Pack years of cigarette smoking	all	0.050	**0.311**	0.130	1.010
	PAT	0.541	**0.238**	0.047	-1.180
	MFC	0.137	**0.332**	0.127	0.970
	MT	0.034	**0.117**	0.045	1.570
	LFC	0.042	**0.100**	0.050	1.650
	LT	0.100	**0.429**	0.054	0.790
Fat consumption	all	0.112	**0.031**	0.118	2.170
	PAT	0.771	**0.992**	0.037	0.010
	MFC	0.810	**0.090**	0.125	1.700
	MT	0.019	**0.035**	0.043	2.120
	LFC	0.420	**0.169**	0.051	1.380
	LT	0.058	**0.053**	0.051	1.940

Fig. 2: Mean P-values and adjusted P-Values, R-square and t-ratio for T2 values at the knee for linear parameters. Results are presented for global T2 values as well as for each compartment.

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CAN LOW RESOLUTION DUAL ENERGY X-RAY ABSORPTIOMETRY IMAGES BE USED TO GRADE OSTEOARTHRITIS SEVERITY?

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Purpose: Currently plain radiographs are routinely used to facilitate diagnosis and monitor progression of hip osteoarthritis (OA). There are several scoring systems that can be applied to grade the severity of OA. The most commonly used is the Kellgren and Lawrence system (KL).

Dual energy x-ray absorptiometry (DXA) scanners are used to determine bone mineral density and diagnose osteoporosis (OP). Image outputs from modern DXA machines are not dissimilar to radiographs and have a lower radiation exposure.

We have previously shown that high resolution images taken from a Lunar iDXA scanner (GE Lunar, Madison, WI, USA) can be used to KL grade hip OA and that this is comparable to KL grading in radiographic images. However, most DXA scanners used in clinical practice are of a lower resolution.

The aim of this study was to determine whether low resolution DXA images taken from two of the most widely used DXA scanners in clinical practice could be used to reliably grade OA of the hip.

Methods: A random sample of 100 images were taken from a database of Hologic QDR4500 Acclaim densitometer (Hologic Inc, Massachusetts USA) images (baseline images of the MRC Clodronate study) and similarly 106 images from a database of Lunar Prodigy (GE Lunar, Madison, WI, USA) images (Osteoporosis and Ultrasound Study (OPUS), Aberdeen centre). All images were anonymised and viewed using the program Image J to enable brightness, contrast and magnification to be altered. Each image was scored twice, at least one week apart, by a trained reader (EN). The reader was blinded to the first reading during the second to reduce expectation bias. Quadratic Weighted Kappa (QWK) statistics (MedCalc v11.5.1) were used to assess repeatability.

Results: See Table 1. No large disagreements (difference in KL grade >1) were found between the two Hologic readings. Three disagreements of >1 KL grade were found between the two Lunar Prodigy readings.

Table 1. QWK statistics for each DXA scanner. Repeatability of KL scoring in DXA images (Quadratic Weighted Kappa Statistics). QWK for radiograph and iDXA images are also included for comparison

Modality comparator	Quadratic weighted Kappa	Standard Error	95% Confidence intervals
Hologic_1/Hologic_2 (n = 100)	0.884	0.023	0.839–0.929
Prodigy_1/Prodigy_2 (n = 106)	0.814	0.042	0.733–0.896
Radiograph_1/Radiograph_2 (n = 50)	0.891	0.030	0.833–0.949
iDXA_1/iDXA_2 (n = 50)	0.938	0.021	0.897–0.980

Conclusions: These data demonstrate that images taken from clinically used DXA scanners can be used to reliably KL grade hip OA. The QWK values for both the Hologic QDR 4500 and Lunar Prodigy were comparable to those previously obtained in radiographs and high resolution iDXA images. Data from the two low resolution scanners suggest that KL grading was slightly more repeatable in the Hologic QDR 4500 images than the Lunar Prodigy.

This is the first study to demonstrate that hip KL grading using low resolution DXA scanner images is repeatable although further work is required to directly compare KL grading in radiographs and low resolution images.

Using DXA images to grade OA severity in a clinical setting could potentially reduce patient radiation exposure and hospital visits.

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LONGITUDINAL CHANGES OF MRI-DETECTED OSTEOARTHRITIS FEATURES IN KELLGREN-LAWRENCE GRADE 4 KNEES. DATA FROM THE MOST STUDY

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Purpose: Kellgren-Lawrence grade 4 (KL4) knees are currently considered radiographic 'end-stage' knee OA (bone-on-bone appearance) which theoretically cannot progress further. We examined what proportion of KL 4 knees at baseline demonstrate further progression longitudinally in regard to features only detectable by MRI, i.e. cartilage, bone marrow lesion (BML), meniscus, Hoffa-synovitis, and effusion-synovitis.

Methods: We studied subjects from the Multicenter Osteoarthritis Study who had KL4 knees at baseline and had baseline and 30-month MRI. Cartilage, BML, meniscus, Hoffa-synovitis, and effusion-synovitis were semiquantitatively scored using the WORMS system in the 5 subregions of the medial and lateral tibiofemoral (TF) compartments of the knee: central and posterior femoral, anterior, central and posterior tibial subregions. WORMS score ranges from 0–6 where 6 represents cartilage loss to bone in 75% of region. Analysis was performed for the compartment showing bone-on-bone appearance ("index") on radiograph and also for the other TF compartment of the same knee. Hoffa-synovitis and effusion-synovitis were assessed for the whole knee. Changes in scores at follow-up were noted for each feature. For cartilage and BML, within-grade changes were also recorded.

Results: 67 knees from 63 subjects were included (51% women, 84% White, mean age 65.1±8.6 years, mean BMI 30.2±5.2 kg/m2). At baseline, in the index TF compartment, all knees showed severe cartilage loss (max WORMS score from 5 subregions was 5 in 1 knee and 6 in 66 knees), 54 knees (80%) showed moderate to large BMLs (max WORMS score 2 or 3), and 62 knees (94%) had severe meniscal lesions (i.e. displaced tear or maceration). In the other TF compartment, 12 knees (18%) had severe cartilage loss, but 47 (71%) had no BML and 57 (97%) had no meniscal damage. 39 knees (58%) had moderate to severe effusion-synovitis, 56 knees (86%) had mild or moderate Hoffa-synovitis. Longitudinally, 22 index compartments (35%) showed an increase in the sum of cartilage scores from all subregions, and 2 (3%) showed increase in the maximum cartilage score. In the other TF compartment, 22% showed an increase in the sum score for cartilage damage, while 15% showed increase in maximum score. For BMLs in the index TF compartment, 19 knees (31%) showed an increase in maximum score and 11 (18%) showed a decrease. Fluctuation of BMLs was also seen in the other TF compartment, but to a lesser extent. Meniscal status mostly remained the same in the index (98%) and other TF (95%) compartments. Effusion-synovitis worsened in 15 knees (27%) and improved in 2 knees (4%). Hoffa-synovitis worsened in 6 knees (11%) and improved in 2 knees (4%).

Conclusion: In KL4 knees, MRI detected progression of cartilage loss, effusion-synovitis, and Hoffa-synovitis, and fluctuation in size of BMLs. Meniscal damage remained stable. Our findings support the idea that disease progression still occurs in KL4 knees. KL4 knees can be a potential target for assessing therapeutic interventions and should not necessarily be excluded from studies evaluating therapeutic response.

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GEOMETRY OF THE ARTICULAR CARTILAGE OF THE TIBIAL PLATEAU IS RELATED TO ANTERIOR CRUCIATE LIGAMENT INJURY RISK

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Purpose: Injuries to the Anterior Cruciate Ligament (ACL) of the knee are common and can lead to post traumatic osteoarthritis (PTOA). Recent studies have shown that tibial plateau geometry may play an important role in controlling transmission of intersegmental forces across the the knee during weight-bearing activity. Factors that have been shown to influence the risk of ACL injury explored thus far have focused on subchondral bone geometry, and include the depth of the concave surface of the medial tibial plateau and the posterior-inferior directed slopes of the medial and lateral plateaus of the tibia. The goal of our study was to build on prior studies of bony geometry by studying the influence of the articular cartilage geometry of the tibial plateau on the risk of suffering ACL injury.

Methods: The study used a matched case-control design. Knee MRI images of 20 ACL injured cases and 20 uninjured controls matched by age and sports team were obtained in order to control for exposure. The DICOM images were uploaded into a viewer program (Osirix, Pixmeo, version 3.6.1., open-source). Using the Cintiq digitizing tablet (Wacom, 2010), the cartilaginous articular surface of the medial tibial plateau was segmented in a standardized and reproducible coordinate system aligned with the tibia. The maximum depth of concavity in the tibial plateau was defined as the point with the greatest depth of concavity within the central 20% of the total surface area. For each of the 40 knees that were segmented, the data points defining the sagittal profiles that contained this value were subsequently used in the statistical analysis. A hierarchical mixed model was used to fit fourth order polynomials to the sagittal profile data. Interaction terms were included in the model as fixed effects to permit the regression coefficients to vary between cases and controls. Variation in the coefficients between individuals and deviations between the estimated and observed data points within individuals were modeled as random effects. Model parameters were estimated by maximum likelihood and the difference in the fit of models with and without the interaction terms was assessed by the likelihood ratio test.

Results: Polynomial fit lines for medial tibial geometry (Figure 1) were significantly different between cases and controls ($p < 0.001$). Polynomial fit equations are as follows:

Case: $-0.5682 + 0.041495x + 0.007804x^2 - 0.000045x^3 - 0.00001143x^4$

Control: $-0.6073 + 0.03446x + 0.007512x^2 - 0.00013x^3 - 0.00001x^4$

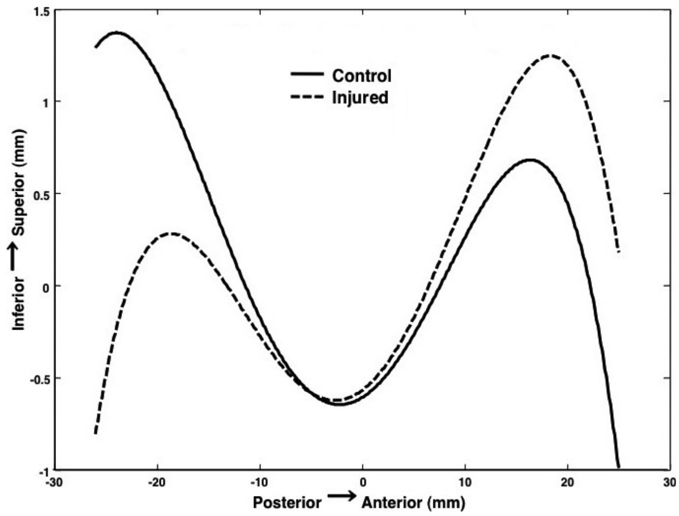

Fig. 1. Polynomial fits of sagittal articular cartilage profiles.

Conclusions: There was a significant difference in tibial articular surface morphometry measured using the fourth order polynomial models between ACL injured case subjects and uninjured matched controls. Uninjured controls appeared to have a tibial articular cartilage profile that conformed to the femoral condyle, while this was not the case for the injured subjects. The increased conformity in uninjured controls was characterized by a substantial increase in the depth of concavity that may act to control the joint biomechanics, particularly during impulsive loading conditions when the knee transitions from non-weightbearing to weightbearing conditions such as during an ACL injury. This divergence of shape of the articular cartilage may further our understanding of how the forces transmitted across the knee influence risk of ACL injury, how individual knee joints respond to loading, and subsequent risk of development of PTOA.

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BEZIER CURVES FOR MEASURING JOINT SPACE ON KNEE RADIOGRAPHS – REPRODUCIBILITY AND VALIDITY

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Purpose: Radiographic joint space width (JSW) is a key feature for evaluating severity and progression of knee osteoarthritis. Computerized methods for evaluating JSW are ideal for large studies, but fully-automated programs which detect bone edge are not as accurate on older digitized plain-film radiographs while manual methods are time consuming. We explored using manually placed Bézier curves to automatically find several measures of JSW, and compared minimum JSW with a manual digital measure.

Methods: 25 digitized plain-film and 25 digital knee radiographs from the Chingford cohort were selected with a range of disease severity (K&L 0–4). Minimum JSW (minJSW) as measured by digital calipers placed by the user was the 'gold-standard' measure. Mean and minimum JSW measurements were calculated based on the Bézier curve, with a user selected point to constrain the area of analysis (outer slopes of the tibial spines) as well as an automated constraint point selected by the program based on curvature. Two observers (KL and DH) completed two training sessions before independently reading the radiographs in a random order, with KL re-reading all radiographs after several days. Intra and inter-observer reproducibility was tested using intraclass correlations (ICC)